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INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁶ : H04N	A2	(11) International Publication Number: WO 98/30015 (43) International Publication Date: 9 July 1998 (09.07.98)
(21) International Application Number: PCT/IL97/00394 (22) International Filing Date: 30 November 1997 (30.11.97) (30) Priority Data: 119928 29 December 1996 (29.12.96) IL (71) Applicant (for all designated States except US): RAMOT UNIVERSITY AUTHORITY FOR APPLIED RESEARCH & INDUSTRIAL DEVELOPMENT LTD. [IL/IL]; P.O. Box 39296, 61392 Tel Aviv (IL). (72) Inventor; and (75) Inventor/Applicant (for US only): COHEN-OR, Daniel [IL/IL]; Elazar 3, Neve Neeman, 45241 Hod Hasharon (IL). (74) Agent: FRIEDMAN, Mark, M.; Beit Samueloff, 7 Haomanim Street, 67897 Tel Aviv (IL).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>Without international search report and to be republished upon receipt of that report.</i>
(54) Title: MODEL-BASED VIEW EXTRAPOLATION FOR INTERACTIVE VIRTUAL REALITY SYSTEMS (57) Abstract A method by which a client and a server cooperate to render views of a virtual reality world within which a user of the client navigates. The server sends the client a reference view and a model to use to extrapolate the reference view in response to the user's virtual movement. The client sends the server a record of the user's virtual movement. Both the client and the server perform the model-based extrapolation of the reference view. The server also performs an exact update of the reference view. When the extrapolated reference view deviates too much from the updated reference view, the server sends the client the difference between the extrapolated and updated reference views, so that the client can update its reference view.		

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MODEL-BASED VIEW EXTRAPOLATION FOR INTERACTIVE VIRTUAL REALITY SYSTEMS

5 FIELD AND BACKGROUND OF THE INVENTION

The present invention relates to interactive networks and, more particularly, to a network in which a server interactively provides views of a virtual reality world to a client.

Unlike text-based media, video must be transmitted in a predictable,
10 synchronized manner, and requires a guaranteed quality of service, with guaranteed bandwidth and guaranteed bounds on other properties such as latency and jitter. Protocols that support guaranteed quality-of-service media connections soon will be provided by ATM-based networks, or by other technologies such as FDDI and Fast
Ethernet. Such protocols establish a virtual connection between a sender (a
15 multimedia server) and a receiver (a client) provided that sufficient resources can be reserved along the path to support the minimum level of quality of service required by the connection.

Photo-realistic virtual reality applications are similar to video-based real-time applications, but provide full interaction. In many virtual reality systems, the user
20 must have a real perception of the environment that is being explored or discovered, and a smooth interaction with the environment. In an interactive web-system scenario, the client carries the virtual camera and navigates through the virtual environment. The server constantly receives details regarding the client camera position and orientation, as well as its activities which may modify the virtual
25 environment. All the information concerning the entire setting is held at the server.

According to the client movement, the server updates the client with essential data which enables the generation of new views.

Time lag and low quality images are the main reasons for a decrease in the sense of reality. High fidelity and photo-realism are achieved by using a fully textured (photo-mapped) environment. Today we are witnessing a rapidly increasing presence of 3D virtual worlds on the world wide web, described using a *virtual reality modeling language* (VRML). However, the interaction with remote virtual environments on the web is still extremely limited. The common approach is to first download the entire VRML 3D world to the client. Then the client renders the scene locally. This approach is successful as long as the environment is not too complex; otherwise it causes a critical penalty in the downloading time. This prevents the use of photo-textures, which are necessary for a photo-realistic impression. It should be emphasized that the downloading time is required for every change of session, for example, if the user moves to an upper floor in a shopping application or to another planet in a video game.

To avoid the above drawbacks, an alternative approach has been suggested in which the server computes the new views and sends them compressed to the client. Although each image is compressed (e.g., JPEG), the volume of transmission is still quite large and would either require an expensive bandwidth or lower the quality of the images. Video compression techniques such as MPEG, which exploit temporal data redundancy, are based on inter-frame dependencies and may be compressed on-line, but with a time lag which prohibits real-time feedback.

There is thus a widely recognized need for, and it would be highly advantageous to have, a method for providing views of a remote complex virtual

reality world, at the client of an interactive server-client system, fast enough to preserve the illusion of virtual reality.

RELATED WORK

5 In visual navigation applications there is always a need to balance the imaging quality and the frame rate. In interactive real-time systems, one is required to maintain a user-specified minimal frame rate. T. A. Funkhouser and C. H. Séquin (Adaptive display algorithm for interactive frame rates during visualization of complex virtual environments, *Computer Graphics (SIGGRAPH '93 Proceedings)*,
10 pp. 247-254, August 1993) proposed an algorithm that adjusts the image quality adaptively by choosing the level-of-detail and rendering algorithm according to its estimated rendering cost. P. W. C. Maciel and P. Shirley (Visual navigation of large environments using textured clusters, *1995 Symposium on Interactive 3D Graphics*, pp. 95-102, April 1995) suggested the use of an imposture to trade speed for quality.
15 An imposture must be faster to draw than the true model while visually resembling the real image. Textures mapped on simplified models are a common form of imposture. J. Shade, D. Lischinski, D. H. Salesin, J. Snyder and T. Deroose (Hierarchical image caching for accelerated walkthroughs of complex environments, *Computer Graphics (SIGGRAPH '96 Proceedings)*), G. Schauffler and W. Sturzlinger (A three
20 dimensional image cache for virtual reality, *Eurographics '96, Computer Graphics Forum* Vol. 15 No. 3 pp. 227-235, 1996) and D. G. Aliaga (Visualization of complex models using dynamic texture-based simplification, *Proceedings of Visualization 96*) all used a single texture polygon. These image-based primitives are view-dependent and form a compact representation: thus they have the potential to be more

appropriate in applications which also need to sustain a user-specified communication bandwidth.

S. Eric Chen and L. Williams (View interpolation for image synthesis, Computer Graphics (*SIGGRAPH '93 Proceedings*), pp. 279-288, August 1993) and T. Kaneko and S. Okamoto (View interpolation with range data for navigation applications, *Computer Graphics International*, pp. 90-95, June 1996) generated novel images from a number of precalculated *reference* images by "view interpolation". Along with the images, corresponding maps are necessary so that one image can be morphed into another. The user can stroll through restricted paths connecting successive locations at which the precomputed views are stored, providing the sensation of continuous in-between views.

The advantage of view interpolation and any other image-based rendering technique is that the generation of a new image is independent of the scene complexity. The technique gives more freedom than strolling back and forth within a video sequence. However, it works well only if adjacent images depict the same object from different viewpoints. The interpolated views may introduce some distortions because linear interpolation does not ensure natural or physically valid in-between images. Recently, S. M. Seitz and C. R. Dyer (View morphing, Computer Graphics (*SIGGRAPH '96 Proceedings*)) proposed a new method, called "view morphing", which better preserves the in-between shape appearance. Image-based methods usually do not consider the underlying 3D model, and some inherent problems, known as holes and overlaps, need to be alleviated. In the paper by Kaneko and Okamoto cited above, a full range of data, acquired from a range scanner, is associated with each reference image. The exact range simplifies the generation of the

in-between images. No correspondence is required, and overlaps are easily resolved by a Z-buffer approach. P. E. Debevec, C. J. Taylor and J. Malik (Modeling and rendering architecture from photographs: a hybrid geometry- and image-based approach, *Computer Graphics (SIGGRAPH '96 Proceedings)*) use a set of viewpoints
5 to approximate the 3D model, and new views are then rendered from arbitrary viewpoints by a view-dependent texture-mapping technique.

SUMMARY OF THE INVENTION

According to the present invention there is provided, in a system in which a
10 server and a client cooperate to render a plurality of views of a virtual world, each view corresponding to a viewpoint, a method for generating the views in real time, comprising the steps of: (a) transmitting a first reference view to the client; (b) transmitting at least a portion of a model to the client; (c) extrapolating said first reference view, based on said at least portion of said model, thereby providing an
15 extrapolated view; (d) transmitting at least one correction dataset to the client; and (e) correcting said extrapolated view based on said at least one correction dataset, thereby providing at least one second reference view.

According to the present invention there is provided, In a system in which a server and a client cooperate to render a plurality of views of a virtual world, a method
20 for updating the views in real time, comprising the steps of: (a) transmitting a first reference view to the client; (b) extrapolating said first reference view, thereby providing an extrapolated view; (c) transmitting at least one correction dataset to the client; and (d) correcting said extrapolated view based on said at least one correction

dataset, thereby providing at least one second reference view; wherein said extrapolating is effected at least twice before said correcting.

The present invention is based on a new paradigm for interaction with complex virtual worlds, on a network such as the world wide web, which uses both
5 the client and the server simultaneously. The client generates (extrapolates) the new views based on the locally available data, while the server transmits only the data necessary to prevent an accumulation of errors. The "polygon-assisted" compression introduced by Marc Levoy (Polygon-assisted JPEG and MPEG compression of synthetic images, *Computer Graphics (SIGGRAPH '95 Proceedings)*, pp. 21-28,
10 August 1995) was previously suggested to partition the rendering task between the server and the client. The client renders a low-quality image and receives from the server the compressed difference between the high-quality image and the low-quality image. This requires the transmission of the difference image for every frame, in contrast to the present invention, wherein the client can generate several frames
15 autonomously.

The present invention is based on the principle of view interpolation discussed above. It enables the user to have a smooth "exploration" of the virtual environment in which (s)he is traveling. However, the present invention does not interpolate between precomputed views, but "extrapolates" the last reconstructed reference view
20 towards the new view.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is herein described, by way of example only, with reference to the accompanying drawings, wherein:

FIG. 1 is a flow diagram of the model-based extrapolation scheme;

FIG. 2 is a flow diagram of novel view generation.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

5 The present invention is of a method for rendering views of a virtual reality world, at the client of any interactive client-server network, from the full world wide web to even a simple communication line, fast enough to preserve the illusion of virtual reality.

Consider an interactive web-system in which the user roams in a remote
10 virtual environment. According to the present invention, the client extrapolates the new views based on the locally available data, which include previous images, camera position and range data. Because the client cannot extrapolate the exact new view, the server needs to transmit to the client a correction dataset, for example a difference image, representing the difference between the client approximated view and the exact
15 new view. The correction dataset is better compressed and reduces the network transmission volume. Moreover, the server does not need to correct the client-extrapolated view in every frame, but at lower frequencies than the client frame rate, to further reduce the network requirements. A novel view $R + i$ is an extrapolation of a reference view R . The server needs to transmit correction datasets to guarantee that
20 the reference view is sufficiently close to the current frame to improve the quality of the extrapolated views. Because the transmitted data do not necessarily reconstruct the current view, no latency occurs.

The extrapolation of the novel view is based on a *model-based* backprojection technique. Maneesh Agrawala, Andrew Beers and Navin Chaddha (Model-based

motion estimation for synthetic animations, *Proc. ACM Multimedia '95*) and D. S. Wallach, S. Kunapalli and M. F. Cohen (Accelerated MPEG compression of dynamic polygonal scenes, *Computer Graphics (SIGGRAPH '94 Proceedings)*, pp. 193-197. July 1994) used model-based techniques for synthetic animations to guide the motion estimation for block-based video compression algorithms. These techniques show that a model-based approach significantly improves the exploitation of inter-frame coherence. In the view extrapolation scheme, the motion compensation is computed by the client and need not be transmitted. Only the difference values need to be transmitted. In terms of network requirements, this guarantees a higher bitrate compression (lower bandwidth requirement) or higher image quality.

The virtual environment consists of textured models stored at the server. The model of the relevant parts is transmitted to the client according to its relative position within the viewer. The transmitted model includes only its geometry and no textures. (It should be emphasized that the texture-space can be significantly larger than the geometry-space.) The transmitted model may include all or only part of the geometry of the true model, or may be an approximation of the geometry of all or part of the true model. The 3D model does not need to be constantly transmitted over the network, but can be transmitted incrementally, and is dynamically transformed by the client. The server only transmits the model data when new models enter the viewing frustum or when a new level of detail of an existing model is required.

Referring now to the drawings, Figure 1 is a block diagram of the model-based extrapolation scheme of the present invention. The scheme is initialized by the transmission from the server to the client of both the portion *M* of the model that is needed to reconstruct the view of the virtual reality world from the client's initial

viewpoint, and an exact reference view R from that viewpoint. The user navigates through the virtual reality world by entering coordinates of new viewpoints. Both the client and the server transform model M to the new viewpoints. The transformed model M is combined with reference view R , as described below, to provide an extrapolated view W . This also is done by both the client and the server. Meanwhile, the server computes exact views V that correspond to the new viewpoints, using the full model as well as texture T . As needed, the server computes correction datasets and transmits them to the client, which used the correction datasets to correct reference view R . According to the embodiment of the present invention depicted in Figure 1, the correction dataset is the difference D between an exact view V and a corresponding extrapolated view W : $D = V - W$. D is transmitted to the client and composed with W (in this embodiment by adding D to W) to give an updated reference view R . Again, this composition is done by both the client and the server, so that the server always has available to it the state of the client. Optionally, as shown in Figure 1, the server compresses D to a compressed difference image D' before transmission to the client. If a lossy compression such as JPEG is used, then the new reference view R is only an approximation of V . If a lossless compression is used, then the new R is identical to V .

Also as needed, additional portions of the model are transmitted from the server to the client, so that the client always has as much of the model as it needs to extrapolate to new viewpoints.

The extrapolation scheme of the present invention is in a sense similar to MPEG compression technology. An MPEG video stream consists of intra frames (I), predictive frames (P) and interpolated frames (B). The I frames are coded

independently of any other frames in the sequence, while the P and B are coded using motion estimation and interpolations. The P and B frames are substantially smaller than the I frames. The motion estimation of a P frame is based on preceding frames as well as successive frames. According to the present invention, successive frames are
5 not available, and instead of the P and B frames, only extrapolated frames **W** are used.

Figure 2 is a flow diagram of the generation of a novel view according to the present invention. This is done in three steps. The first step renders model **M** to create a Z-map. The second step generates extrapolated view **W** by backprojecting to reference view **R**. The third step corrects warped view **W** using the transmitted data,
10 including the correction dataset. As noted above, the third step is performed only as needed, and not necessarily in every cycle.

The embodiment of the invention described herein uses only one reference view for view extrapolation, and uses a difference image as an correction dataset. It will be appreciated that these are not inherent limitations of the invention. The scope
15 of the invention includes other kinds of correction datasets, and extrapolation based on several reference views, as will be obvious to one ordinarily skilled in the art.

While the invention has been described with respect to a limited number of embodiments, it will be appreciated that many variations, modifications and other applications of the invention may be made.

WHAT IS CLAIMED IS:

1. In a system in which a server and a client cooperate to render a plurality of views of a virtual world, each view corresponding to a viewpoint, a method for generating the views in real time, comprising the steps of:

- (a) transmitting a first reference view to the client;
- (b) transmitting at least a portion of a model to the client;
- (c) extrapolating said first reference view, based on said at least portion of said model, thereby providing an extrapolated view;
- (d) transmitting at least one correction dataset to the client; and
- (e) correcting said extrapolated view based on said at least one correction dataset, thereby providing at least one second reference view.

2. The method of claim 1, wherein said extrapolating is effected by the steps of:

- (i) transforming said model to the viewpoint of said extrapolated view;
- (ii) rendering said model; and
- (iii) backprojecting said model to said first reference view.

3. The method of claim 1, further comprising the steps of:

- (f) rendering an exact view, by the server; and
- (g) subtracting said extrapolated view from said correct view, thereby providing a difference image to use as one of said at least one correction dataset.

4. The method of claim 3, further comprising the step of:

(h) compressing said difference image.

5. The method of claim 1, further comprising the step of:

(f) replacing said first reference view with one of said at least one second reference view.

6. The method of claim 1, wherein said correction dataset includes a difference image.

7. In a system in which a server and a client cooperate to render a plurality of views of a virtual world, a method for updating the views in real time, comprising the steps of:

(a) transmitting a first reference view to the client;

(b) extrapolating said first reference view, thereby providing an extrapolated view;

(c) transmitting at least one correction dataset to the client; and

(d) correcting said extrapolated view based on said at least one correction dataset, thereby providing at least one second reference view;

wherein said extrapolating is effected at least twice before said correcting.

8. The method of claim 7, further comprising the steps of:
 - (e) rendering an exact view, by the server; and
 - (f) subtracting said extrapolated view from said correct view, thereby providing a difference image to use as one of said at least one correction dataset.
9. The method of claim 8, further comprising the step of:
 - (g) compressing said difference image.
10. The method of claim 7, further comprising the step of:
 - (e) replacing said first reference view with one of said at least one second reference view.
11. The method of claim 1, wherein said correction dataset includes a difference image.

1/1

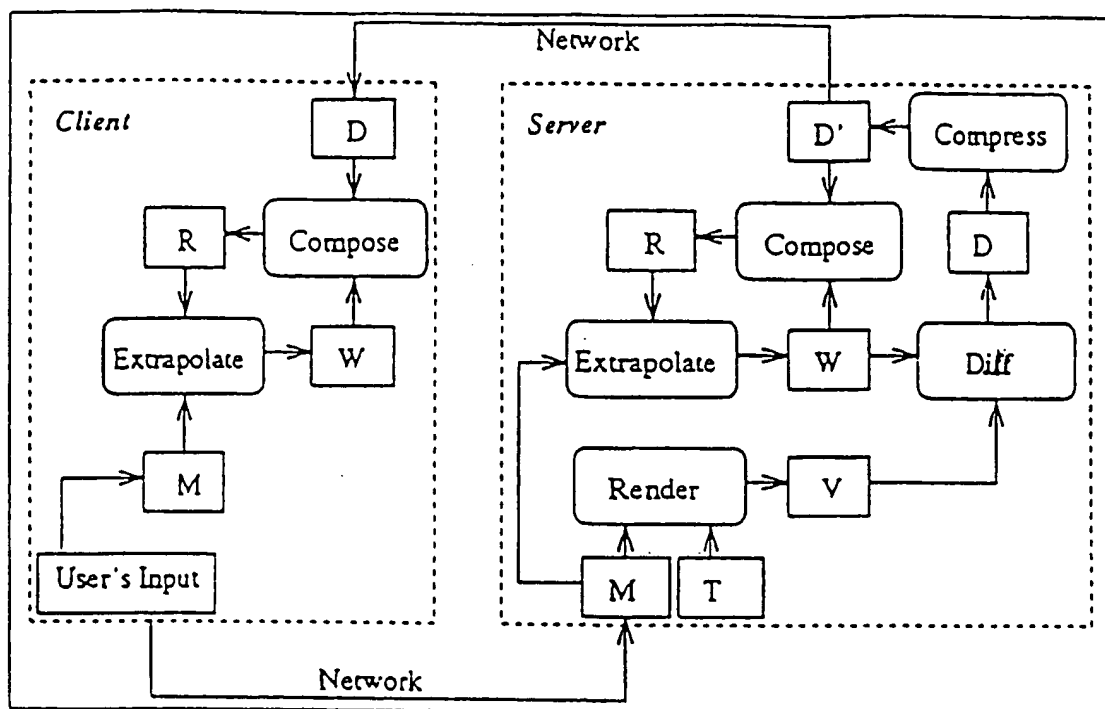


Figure 1:

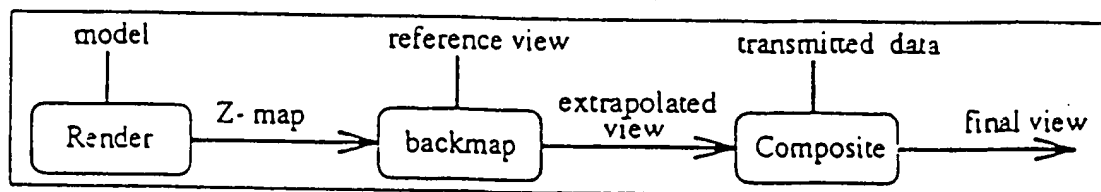


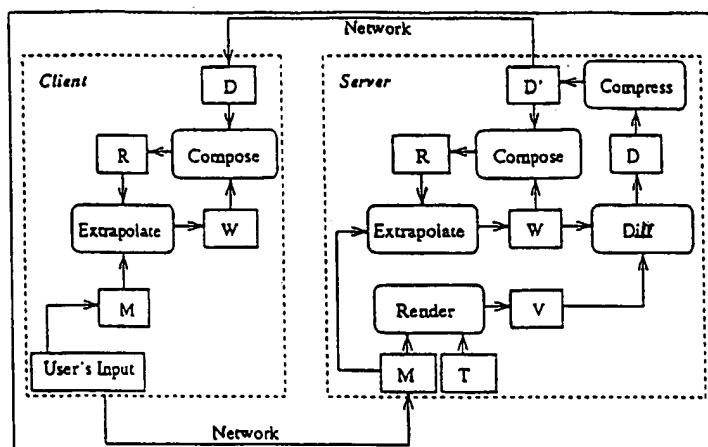
Figure 2:



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(54) Title: MODEL-BASED VIEW EXTRAPOLATION FOR INTERACTIVE VIRTUAL REALITY SYSTEMS

**(57) Abstract**

A method by which a client and a server cooperate to render views of a virtual reality world within which a user of the client navigates. The server sends the client a reference view (R) and a model to use to extrapolate the reference view in response to the user's virtual movement. The client sends the server a record of the user's virtual movement (M). Both the client and the server perform the model-based extrapolation of the reference view. The server also performs an exact update of the reference view. When the extrapolated reference view deviates too much from the updated reference view, the server sends the client the difference (D) between the extrapolated and updated reference views, so that the client can update its reference view.

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EE	Estonia						

<p>(51) International Patent Classification ⁶ : G06T 15/70</p>	<p>A3</p>	<p>(11) International Publication Number: WO 98/30015</p> <p>(43) International Publication Date: 9 July 1998 (09.07.98)</p>
<p>(21) International Application Number: PCT/IL97/00394</p> <p>(22) International Filing Date: 30 November 1997 (30.11.97)</p> <p>(30) Priority Data: 119928 29 December 1996 (29.12.96) IL</p> <p>(71) Applicant (for all designated States except US): RAMOT UNIVERSITY AUTHORITY FOR APPLIED RESEARCH & INDUSTRIAL DEVELOPMENT LTD. (IL/IL); P.O. Box 39296, 61392 Tel Aviv (IL).</p> <p>(72) Inventor; and</p> <p>(75) Inventor/Applicant (for US only): COHEN-OR, Daniel (IL/IL); Elazar 3, Neve Neeman, 45241 Hod Hasharon (IL).</p> <p>(74) Agent: FRIEDMAN, Mark, M.; Beit Samueloff, 7 Haomanim Street, 67897 Tel Aviv (IL).</p>		<p>(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, ID, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ZW, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG).</p> <p>Published <i>With international search report.</i> <i>With amended claims.</i></p> <p>(88) Date of publication of the international search report: 22 October 1998 (22.10.98)</p> <p>Date of publication of the amended claims: 10 December 1998 (10.12.98)</p>

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graph TD
    subgraph Client
        UI[User's Input] --> M1[M]
        M1 --> E1[Extrapolate]
        E1 --> W1[W]
        W1 --> C1[Compose]
        C1 --> R1[R]
        R1 --> D1[D]
    end

    subgraph Server
        M2[M] --> R2[Render]
        T[T] --> R2
        R2 --> V[V]
        V --> Diff[Diff]
        Diff --> W2[W]
        W2 --> E2[Extrapolate]
        E2 --> C2[Compose]
        C2 --> R2
        C2 --> D2[D]
        D2 --> Comp[Compress]
        Comp --> Dp[D']
    end

    D1 -- Network --> Dp
    Dp -- Network --> M2
    E2 -- Network --> E1
    
```

The diagram illustrates the Client and Server architectures for a distributed system. The Client architecture (left) includes a User's Input block, a block M, an Extrapolate block, a block W, a Compose block, a block R, and a block D. The Server architecture (right) includes a block M, a block T, a Render block, a block V, an Extrapolate block, a block W, a Diff block, a Compose block, a block D, a block D', and a Compress block. Data flows are indicated by arrows: User's Input to M, M to Extrapolate, Extrapolate to W, W to Compose, Compose to R, R to D. On the Server, M and T feed into Render, which feeds into V, which feeds into Diff. Diff feeds into W, which feeds into Extrapolate, which feeds into Compose. Compose feeds into D, which feeds into Compress, which feeds into D'. D' feeds back into the Network, which feeds back into M. Additionally, there is a direct connection from the Client's Extrapolate block to the Server's Extrapolate block via the Network.

A method by which a client and a server cooperate to render views of a virtual reality world within which a user of the client navigates. The server sends the client a reference view (R) and a model to use to extrapolate the reference view in response to the user's virtual movement. The client sends the server a record of the user's virtual movement (M). Both the client and the server perform the model-based extrapolation of the reference view. The server also performs an exact update of the reference view. When the extrapolated reference view deviates too much from the updated reference view, the server sends the client the difference (D) between the extrapolated and updated reference views, so that the client can update its reference view.

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AMENDED CLAIMS

[received by the International Bureau on 27 October 1998 (27.10.98);
original claims 1-11 replaced by new claims 1-29 (3 pages)]

1. In a system in which a server and a client cooperate to render a plurality of views of a virtual world, each view corresponding to a viewpoint, a method for generating the views in real time, comprising the steps of:

- (a) transmitting a first reference view to the client;
- (b) transmitting at least a portion of a model to the client;
- (c) extrapolating said first reference view, based on said at least portion of said model, thereby providing an extrapolated view;
- (d) transmitting at least one correction dataset to the client; and
- (e) correcting said extrapolated view based on said at least one correction dataset, thereby providing at least one second reference view.

2. The method of claim 1, wherein said extrapolating is effected by the steps of:

- (i) transforming said model to the viewpoint of said extrapolated view;
- (ii) rendering said model; and
- (iii) backprojecting said model to said first reference view.

3. The method of claim 1, further comprising the steps of:

- (f) rendering an exact view, by the server; and
- (g) subtracting said extrapolated view from said exact view, thereby providing a difference image to use as one of said at least one correction dataset.

4. The method of claim 3, further comprising the step of:

- (h) compressing said difference image.

5. The method of claim 1, further comprising the step of:

- (f) replacing said first reference view with one of said at least one second reference view.

6. The method of claim 1, wherein said correction dataset includes a difference image.

7. The method of claim 1, wherein said extrapolating of said first reference view is effected a plurality of times, thereby providing a plurality of extrapolated views, and wherein said correcting is effected on only a portion of said plurality of extrapolated views.

8. In a system for rendering a plurality of views, each of the views associated with a viewpoint, a method for reconstructing at least one of the plurality of views, comprising the steps of:

- (a) providing a set of at least one reference view;
- (b) providing range data;
- (c) extrapolating said set of at least one reference view based on said range data and on at least one of the viewpoints, thereby providing at least one extrapolated view;
- (d) providing at least one correction dataset; and
- (e) correcting said at least one extrapolated view based on said at least one correction dataset, thereby providing at least one new reference view.

9. The method of claim 8, wherein, for at least one of said at least one reference view, said extrapolating is effected a plurality of times, thereby providing a plurality of extrapolated views, said correcting being effected on only a portion of said plurality of extrapolated views.

10. The method of claim 8, wherein said range data is provided as part of a geometric model.

11. The method of claim 8, further comprising the step of:

- (f) adding said new reference view to said set of at least one reference view.

12. The method of claim 8, wherein said extrapolating includes motion compensation.

13. The method of claim 12, wherein said motion compensation includes backprojection.

14. The method of claim 8, wherein said correction dataset is a difference between an exact view and said extrapolated view.

15. The method of claim 14, further comprising the step of:

- (f) rendering said exact view, based on a virtual reality world.

16. The method of claim 8, further comprising the step of:

- (f) compressing said correction dataset.

17. The method of claim 16, wherein said compressing is effected using a lossy compression.

18. The method of claim 17, wherein said lossy compression is JPEG.
19. The method of claim 8, wherein only enough of said range data is provided to enable said extrapolating.
20. The method of claim 8, wherein said plurality of views are rendered cooperatively by a sender and a receiver.
21. The method of claim 20, wherein said providing of said set of said at least one reference view, said providing of said range data, and said providing of said at least one correction dataset are effected by sending said set of said at least one reference view, said range data and said at least one correction dataset from said sender to said receiver.
22. The method of claim 20, wherein said extrapolating and said correcting are effected both by said sender and by said receiver.
23. The method of claim 20, wherein said receiver includes a client that includes a virtual camera, said at least one viewpoint being provided by said virtual camera, said range data being provided in accordance with said at least one viewpoint.
24. The method of claim 23, wherein said range data is included in a portion of a geometric model sent from said sender to said receiver, said portion of said geometric model being selected according to said at least one viewpoint.
25. The method of claim 23, wherein said range data is included in a portion of a geometric model sent from said sender to said receiver, said portion of said geometric model being selected according to a required level of detail.
26. The method of claim 20, wherein said sender includes a server and wherein said receiver includes a client, said server and said client being connected via a network.
 27. The method of claim 26, further comprising the steps of:
 - (f) establishing at least one of the viewpoints, by said client.
 28. The method of claim 27, further comprising the steps of:
 - (g) providing said at least one viewpoint to said server, by said client; and
 - (h) determining said at least one correction dataset based on said at least one viewpoint, by said server.
 29. The method of claim 27, wherein said establishing of said at least one viewpoint is effected in accordance with user navigation.

INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL97/00394

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :GO6T 15/70

US CL :345/475; 348/399, 400, 401, 402, 409, 415

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 345/475; 348/399, 400, 401, 402, 409, 415

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS search terms: extrapolat?, image, picture, view, difference, correct

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X ----- A	US 4,710,809 A (Ries et al.) 01 December 1987 (01.12.97), see the entire document.	7-11 ----- 1-6
X ----- A	US 5,369,449 A (Yukitake et al.) 29 November 1994 (29.11.94), see the entire document.	7-11 ----- 1-6
A	US 5,414,521 A (Ansley) 09 May 1995 (09.05.95), see the entire document.	1-11



Further documents are listed in the continuation of Box C.



See patent family annex.

* "A"	Special categories of cited documents: document defining the general state of the art which is not considered to be of particular relevance	*T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
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Date of the actual completion of the international search

22 JUNE 1998

Date of mailing of the international search report

31 AUG 1998

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Form PCT/ISA/210 (second sheet)(July 1992)*